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ABSTRACT

After a discussion of the place and purpose of science in the elementary school, and of methods for integrating science topics with language, applied number, art, and social studies, an outline of topics suggested as suitable for children in the Victorian (Australia) elementary schools is given. Suggested teaching activites to develop skills in discrimination and classification, and concepts of interaction and change based on a study of matter, energy and life are listed. (More detailed discussions of techniques of these suggested topics can to be found in SE 012 719, SE 012 720, and SE 012721.) The teacher is encouraged to provide for differences in student interest and ability, and to develop the course through individual student activities. (AL)

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EDUCATION DEPARTMENT, VICTORIA

COURSE OF STUDY

FOR

PRIMARY SCHOOLS

SCIENCE

7192/68.

CONTENTS

THE PLACE AND THE PURPOSE OF SCIENCE IN THE PRIMARY SCHOOL

For young children science is an adventure in thinking, for teachers it can be an adventure in the discovery of children.

To teach science is to embark on an exciting and complex venture. Science is not taught merely to develop appreciation of nature, to convey some facts, or to encourage children to use the skills of science, although it is hoped that all of these things will receive attention.

It is at least equally important that science should be a source of activities which show children's present abilities as thinkers and which also provide opportunities for their further development as thinkers.

Science and Intellectual Growth

Thinking is, at least in part, a process of obtaining information and using it. Information does not come only from a teacher or a book; it flows in from the environment, through all the senses. If either the environment or one of the senses is impaired, through blindness, deafness, poverty, or over-crowding, a child is deprived of an opportunity to obtain experience, and intellectual development may be seriously handicapped. Even where there is no obvious impairment of the senses, a rich and stimulating environment is necessary. Children should be encouraged to explore this environment, using all their senses, or their intellectual development could be restricted. Because science is an investigation of the environment and because it relies so heavily on observational, sensory evidence, it can play an important part in fostering the intellectual development of children.

However, thinking is an active, on-going process, and sensory exploration is only one stage in the process. A characteristic feature of an able thinker is his ability to relate ideas in useful ways, thus showing insight and an awareness of implications. An inability to handle the abstract ideas that are a feature of advanced thought may stem from limitations imposed early in life. Two possible limitations have been mentioned—those of sensory experience and those of environment—but there is also a third, and this has to do with language.

Experience and Language

Where facility with language is limited, thinking is made more difficult, to say the least. In the sphere of intellect, language is pre-eminent as a mediator between the individual and experience. Science is a source of intriguing experiences. These can promote a more effective use of language, including words and other forms of symbolic representation, so that children can be helped to think more effectively.

Science and Other Subject Areas

The teaching of science, however, is not only concerned with the development of intellectual skills. Science is essentially a humanistic enterprise, and intellectual development through science needs to be part of the broader development of children as sensitive, responsive human beings. This means that science has strong links with subjects other than English, including social studies and art. Science is also linked with mathematics.

Science and Mathematics

It has been said that science is "an organized body of knowledge or opinion which is systematically supported by formal proofs or by observational evidence" (*International Encyclopedia of Science*, Nelson, p. 1047), but this is probably not suitable as a definition in the present context. However, it is significant that a definition of this type can include mathematics as well as the observational sciences. The two studies are closely connected. It is possible, and often desirable, that many applied number activities will be derived from work in science.

Science and Social Studies

The past can take on more meaning when work with a donkey engine leads to discussion on the industrial revolution. Discussion of the kind of bow that Robin Hood might have used may create an interest in comparing materials that might be used in bow making; this in turn might lead to investigations of elasticity in a variety of materials.

Science and Art

The links are equally strong between art and science. Sometimes the need to create models or to interpret an event can carry an activity imperceptibly into a realm where artistry and imagination are allowed full play. Furthermore, the whole process of making groupings, and seeing relationships, is basically an imaginative act in itself, reaching the very highest level in works of men such as Newton and Einstein.

The matters discussed above provide sufficient justification for paying serious attention to science, even if it offered nothing more, but science is a classic realm in its own right, and the studies begun in the Beginners Grade form part of an intricate but coherent pattern of scientific learning, the threads of which extend from the discoveries of the smallest child to those of the adolescent and the mature adult.

What Is Science?

At this point it seems profitable to provide a definition of science. Definitions of science present difficulties in that any brief statement is likely to be too compressed for clarity and wide acceptability, but *for present purposes* it may be sufficient to define science *as a study that is based on observational evidence and that also attempts to organize ideas about the material world so that the ideas have some consistency and logic.*

Science as a Developing Body of Knowledge

Science at any level does not pretend to be able to give the whole truth. Any theory that is put forward must be regarded as at least being open to disproof or alteration if and when other evidence becomes available. It is this that makes science a demanding study for many teachers and children. There are no quick and easy solutions. It is relatively easy to present children with the "facts" or the "right" answer, but this may lead children to believe that science is simply another body of factual knowledge to be learned, resting on a firm foundation of some basic truth or fact. Science does embody a great store of factual knowledge, and children will absorb a good deal of it. However, these "facts" and the conceptual schemes built upon them are subject to change. In science one must be satisfied with results that are often inconclusive, resulting in more problems to be answered rather than one final, grand solution. Broadly speaking, this is the situation in which the adult scientist may find himself, and with it we must be content.

Once this is understood it is possible to re-examine the simplified definition and to consider the organized ideas children should be developing as a result of their experiences. These ideas will be related to the materials, both living and non-living, that make up the world, to the forces that operate on these materials, and to the changes that take place. The process of clarifying ideas is aided by the development of certain abilities which are of general use and not applicable to science alone. These abilities include observation, using the appropriate senses, planning and carrying out activities, organizing information through measurement, and the systematic collection of data in the form of simple tables and graphs, the drawing of valid conclusions, and the use of language to facilitate the thinking that the activity should involve. Teachers of very young children may feel that these abilities are set out rather formally, when compared with the operations their children undertake, but abilities that can be distinguished at a later stage depend largely on early experiences in which the germ of these abilities is present and can be nurtured.

The Aims of Science Teaching

It is now possible to consider briefly the aims of the course, but before doing so it may be appropriate to issue a warning. A statement of aims can easily give a formal, cut-and-dried impression of a subject, which at this stage should not be formal or cut-and-dried. Science is a subject that should develop out of children's interests and that remains interesting and enjoyable. This should be kept in mind while the aims are being considered.

It is expected that—

children will develop and enlarge an interest in their environment and in the investigation of it; that they will develop the habit and the ability to ask questions and to formulate ideas; and that they will look for similarities and differences, patterns, and relationships in their surroundings;

children will show an increased willingness and ability to observe, experiment, measure, and weigh; that they will develop the organizational and interpretative skills associated with the tabulation and the graphing of data; and that concurrently, as they develop these abilities, their ability to use language for thinking and communication will also be developed;

children will show a developing understanding of change, cause and effect, time, energy, matter, and the characteristics of life, including the relationship between living things and their environment;

children will become aware of science as part of human activity; they will show an increasing realization that scientific knowledge and approaches have useful applications in daily life, in the areas of human health and the conservation of the environment, and elsewhere.

Evidence of progress towards the achievement of these aims can be obtained by noting carefully the changes and the development in children's thinking as shown by what they say and write and by their approach to the problems and the materials they investigate.

It is expected that selections will be made from all of the sections of the course, thus dealing with some aspects of matter, some of energy, and some of life, and that progress towards achieving all the aims will be made.

The Relationship between the Course and the Curriculum Guide

In covering these sections and achieving these aims, the activities undertaken are likely to vary from class to class, according to the interests of the children as well as the interests of teachers. Therefore, *the material contained in the sections set out on the following pages should be regarded primarily as a synopsis of suggestions which are amplified in the Curriculum Guides.* These suggestions embody an approach that is useful in producing the desired outcomes indicated above. *The activities are not the only ones that are possible,* nor are they necessarily better than others that teachers may care to add from time to time, nor could they all be attempted. There will not be sufficient time. *The Curriculum Guides should be regarded as source materials to be used when and where they are likely to be of most value.*

Finally, it must be emphasized that the section headings are somewhat arbitrary and for some purposes other headings might be equally valid. Science is a unified study which, in this course, has been divided only for convenience in presentation.

THE COURSE

Development in children is a continuous process, and the rate of development varies from child to child. The work undertaken by children in a particular class will depend very largely on their interests. The manner in which each child tackles this work will depend on his particular stage of development and his previous experiences. What might be regarded as "infant" level work for some children may also be suitable for other children in later grades.

For convenience in presentation of the course and guide material a division has been made, but it should not be thought that the division indicates a strict line of demarcation between grades. Nevertheless it has been found that the activities set out under BEGINNING SCIENCE are generally suitable for children in the infant department, whereas the activities set out under FOLLOWING ON and BRANCHING OUT are generally suitable for older children. However, it should be clearly understood that this is not a hard-and-fast division. Children should be encouraged to pursue activities in their individual fashion and at their own level, and teachers should not feel bound by any arbitrary divisions in the Course and the Curriculum Guides.

All teachers should study carefully the course and the guide material on "Discrimination and Classification" and "Interactions and Change", as these are built around ideas that are both useful and important at all levels. In fact, they permeate both the junior and the senior level activities that are set out in FOLLOWING ON *and* BRANCHING OUT *under the headings "Matter", "Energy", and "Life".*

BEGINNING SCIENCE

PART I: DISCRIMINATION AND CLASSIFICATION

The process of discrimination involves the perception of likenesses and differences in things, as the result of close observation using the appropriate senses—sight, hearing, smell, touch, and taste.

The process of classification involves an attempt to bring some order into the information obtained through the senses, by making groups or categories on the basis of similarity or a common property.

Ability to observe and classify at an early stage may well have an important bearing on the subsequent development of a child's ability to handle and group more complex ideas. Therefore, many opportunities must be provided for the child to develop his ability to observe, to discriminate, and to classify, using the appropriate senses.

Discrimination and classification activities play an important part in science at all levels in the primary school, but they are of particular importance in the infant grades. In the Beginners Grade, children may note and discuss fairly simple likenesses and differences. By the time children reach Grade II, they should be capable of making classifications which are both broader and more subtle, taking account of finer and less obvious properties.

Activities can be undertaken with a wide variety of materials. Some suggestions are given below:

- Children, pets, and other animals.
- Plants, twigs, leaves, flowers, seeds, fruits, and vegetables.
- Rocks, shells, soils.
- Fabrics.
- Toys.
- Liquids, powders, crystals,
- Household materials.

More detailed information is contained in the Curriculum Guide.

PART II: INTERACTIONS AND CHANGE

A significant characteristic of human beings is their concern with change—noting change and trying to bring it about. This interest in change can be detected even in very young babies; in older children it is shown by their curiosity and purposeful activity. Education that ignores this human involvement with change will be limited and ineffective. Change is important for children and for their education; it is indispensable for science. Only a small amount of knowledge about the world comes from passive observation. By studying the effects of change and by bringing about change we widen our knowledge immeasurably.

There is another useful notion that should be kept in mind. Science is very much the study of an interactive process. Briefly, nothing exists in isolation, as it is, for long—not a plant, not a nail, not a man, not even a book on a table—all are in constant interaction with the environment. The nail rusts; the man and the plant grow and die, not as isolated units, but as parts of a complex interaction with the environment. Even the position of the book is dependent on the forces operating between it and the table.

The two notions of interaction and change together cover almost the whole realm of science (the study of matter, energy, and life). Taken together they also make an ideal starting point for science at the infant level, but they also permeate the study of science throughout the primary school. In the early school years almost all the work that is undertaken is concerned with interaction and change as it applies to matter, energy, and life.

Interactions and Change: Inanimate Materials

Working with water.

Working with air.

Working with heat.

Other interactions—household materials.

Interactions and Change: Energy and Forces

Working with sounds.

Working with heat.

Working with light.

Working with magnets and batteries.

Working with constructions and toys.

Interactions and Change: Life

Living things taking in material from their surroundings.

Living things and change—growth, reproduction, behaviour.

Varieties of structures.

Human beings seen as being members of a larger group of living things.

Health practices.

Collecting and Caring—

Collecting and caring for plants and animals; caring for humans.

Collections of structures—bones, feathers, hair; worms, mussels, slugs, snails, slaters, spiders, ants, butterflies, moths, caterpillars, fish, frogs, lizards, tortoises, birds, white mice, guinea-pigs, rabbits, etc.

Plants—land and pond plants, flowering plants, conebearers, ferns, mosses, etc.

It is hoped that as a result of this work children's ideas about time will be developed. To this end, activities on the following topics should be undertaken:

Changes with time.

Historical time.

Speed and distance.

Activities Associated with Other Subject Areas

Refer to "Notes on the Course".

The Role of the Teacher

Refer to "Notes on the Course".

FOLLOWING ON and BRANCHING OUT

PART I: MATTER

The activities suggested in the Curriculum Guide are expected to provide a background of experience that will add meaning to later formulations of ideas about the nature of matter. Experience should be associated with discussion and speculation about the nature of matter, based on and consistent with the experiments undertaken and the data collected. Probably, at this level, the most important task is to develop curiosity about the nature and the properties of the materials investigated and about the changes observed. A condition of open-mindedness should be encouraged rather than an unthinking acceptance of a set of unalterable factual statements.

In earlier times, Man speculated about the nature of things, about the stuff of which the universe is made. Among the Greeks, for example, Aristotle upheld the old tradition that the essential elements, from which all things were derived, were fire, water, air, and earth. On the other hand, there were those who put forward a particle theory, according to which all matter was composed of "atoms".

> Material objects are of two kinds, atoms and compounds of atoms. The atoms themselves cannot be swamped by any force, for they are preserved indefinitely by their absolute solidity. Admittedly, it is hard to believe that anything can exist that is absolutely solid. The lightning stroke from the sky penetrates closed buildings, as do shouts and other noises. Iron glows molten in the fire . . . Hard gold is softened and melted by heat . . . Both heat and piercing cold seep through silver, since we feel both alike when a cooling shower of water is poured into a goblet that we hold ceremonially in our hands. All these facts point to the conclusion that nothing is really solid. But sound reasoning and nature itself drive us to the opposite conclusion. Pay attention, therefore, while I demonstrate in a few lines that there exist certain bodies that are absolutely solid and indestructible, namely these atoms which according to our teaching are the seeds or prime units from which the whole Universe is built up.
>
> —Lucretius*

At best, these early ideas contained the germ of the modern approach to the structure of matter—that it comprises anything that occupies space and possesses mass; that it is composed of a number of "elementary" particles, including electrons, protons, and neutrons which are themselves probably no more "fundamental" than the atoms of Lucretius; that matter is basically electrical in nature; that there is still much to be found out about it.

Children in the primary school, however, need not be concerned with such detail. At this level, children should be encouraged to extend their knowledge of matter—by investigating the variety of materials that exist naturally or that can be made; by making a close study of the properties of certain materials; and by attempting to bring about change through the manipulations or "experiments" they undertake. This work should provide a natural extension of ideas suggested in the sections of the Curriculum Guide on "Discrimination and Classification" and on "Interactions and Change".

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* Hurd, D. L., and Kipling, J. J., *The Origins and Growth of Physical Science*, Volume 1, Penguin Books, 1964, page 47.

Collections

It is virtually impossible to give a short list of the materials that could be studied, but the list given below may be of some use :

- Plastics,
- rubbers,
- metals,
- food-stuffs (meat, milk, butter, cheese, flour, vegetables, fruits, herbs, and spices),
- timbers,
- rocks and ores,
- fibres, both man made and natural,
- soluble substances and the solutions they make,
- crystalline substances,
- yeast,
- plaster, cement, and different mixtures of these with sand and water,
- the juices of berries, fruits, and plants generally,
- earths and clays, the pastes they form when water is added, and the colours of these,
- rubber bands and springs,
- gases and liquids in a variety of containers, including bicycle pumps and balloons,
- fats and oils,
- volatile substances, such as perfumes,
- objects of similar mass, but of dissimilar shape and size (to build some elementary understanding of density and of the relationships between mass and volume).

A good deal of this work will involve the making of collections and noting the similarities and the differences that exist among the items. Work may begin with a collection and then continue with the compilation of an "interest book" (e.g. "Our Book of Metals") in which the observations and the tests made by the children are supplemented by information obtained from encyclopedias and other library books or from children with special interests and knowledge.

But this would only be a beginning. It is expected that children will show development in both the range and the level of the investigations they will undertake. An interest in a personal examination of the material will begin to be extended to an interest in the function and the use of the materials, representing a change from what may be termed a personal interest or involvement with the material to an interest in what man in general can do or might do to the materials, including changes which children might themselves be able to bring about.

Properties and Change

Investigations are likely to become centred on properties and on the manipulations which might bring into existence a new set of properties with, possibly, different implications and uses for the manipulator. For example, flour and yeast have certain properties, but when they are combined in a certain way and heated the result is not the sum of these properties, but a new material, bread, with another set of properties altogether. An interest in various types of rubber might lead to a study of elasticity and, perhaps, to the possible implications of this property and its use in weighing devices or in providing the energy source for model aeroplanes.

Some of these changes will be found to be reversible, such as dissolving and recovering a substance or melting and solidifying. Many of the activities serve to indicate and emphasize that much of our knowledge is obtained by bringing about changes, not in any random or pointless fashion, but by careful planning executed as part of an experimental process. While no rigorous experimental procedures are expected from children, these do represent a goal towards which they are moving.

Finally, to accompany the development in thinking that takes place, it is hoped that there will be a growth of interest in the underlying nature of the material itself (e.g. perfume, yeast, crystals, lead) and its basic structure, of which the observed properties may give some indication.

Following On

A. Nature of Materials

(Developing a curiosity about the nature of the materials investigated.)

Collections

Collections are a continuation and an extension of the classification activities begun in the infant school :

- Plastics.
- Metals.
- Foodstuffs.
- Timbers.
- Rocks and ores.
- Fibres.
- Soluble crystalline substances.
- Yeasts, moulds, fungi.
- Plaster, cement, earths, clays.
- Juices of berries, fruits, plants.
- Fats and oils.
- Perfumes and other volatile substances.
- Objects of similar mass but dissimilar in shape and size.

Observations and tests provide information which may be extended by excursions and information obtained from a variety of sources.

These collections are not intended to be static things, but basic material for the manipulations or "experiments" children undertake.

B. Properties and Change

Separating Materials

Mixtures of materials, separated as a result of knowledge of properties such as solubility, fineness, lightness, volatility, magnetic attraction.

Soaps, Fats, and Oils

Testing for presence of oil.

Groupings of collected materials according to various criteria.

Collections of detergents and soaps.

Emulsifying fats, oils.

Cleaning efficiency.

Making soap.

Water in Food

Driving off water.

Adding water.

Collections of dried foods.

Drying fruit, vegetables, herbs, and grasses.

Plaster and Cement

Making "bricks".

Varying recipes.

Testing the strength of bricks.

Solutions, Growing Crystals, Rock Candy

Collections and groupings of soluble materials.

Solvents.

Growing crystals.

Bread, Toffee, Honeycomb, Ginger Beer, and Cheese

Overcoming problems involved in making bread.

Changes due to heat.

Effects of yeast.

Effects of heat on sugar and other materials (e.g. toffee).

Making Perfume

Collections of volatile substances, perfumes, fragrances, lotions, flowers, leaves.

Making sachets, lotions, toilet waters.

Changes of State

See Energy unit "Heating and Cooling".

Rocks

Wearing Away the Earth

Activities Associated with Other Subject Areas

Refer to "Notes on the Course".

The Role of the Teacher

Refer to "Notes on the Course".

Branching Out

A. Nature of Materials

(Observations of materials, providing opportunity for discussion and speculation on the nature of various forms of matter.)

Comparison of Liquids

Floating razor blades.

Measuring strength of surfaces.

Viscosity.

Diffusion through Liquids

Ink in hot water, in cold water, in other liquids.

Solutions.

Separating Materials

Filtering.

Distillation.

Rising Liquids

Observations of capillary action.

Chromatography

Solutions. separations

Hardness, Brittleness, and Elasticity

Measuring height of bounce of hard object striking surfaces.

Rubber bands, plastic tubing, tape, wooden strips.

Threads and Fibres

Testing natural and man-made fibres.

Glass, Bricks, Pots, and a Kiln

Melting glass.

Observation of bricks, making bricks and pots from clays.

Making a simple kiln.

Firing clay objects.

B. Bringing about Change

(Varying and controlling the factors involved in situations. Classifying on the basis of observed change.)

Corrosion

Collection of a wide variety of materials and placing them in different situations (e.g. air, fresh water, salt water, lemon juice.)

Application of coatings to inhibit corrosion.

Results of Change

Observing flames.

Products of burning.

Weighing residues :

candle ;

wood and wood ash ;

steel wool.

Heating rubber, plastics, and fibres.

Boiling an Egg

Observing coagulation.

Interactions between parts of egg and household chemicals.

Effect of chemicals on coagulation.

Relationships between temperature and coagulation.

Making Coal Gas

Converting coal into other susbtances by application of heat.

Comparisons with other materials.

The Souring of Milk

Interactions between milk and various household chemicals.

Changes in milk due to environmental factors.

Observing milk under a microscope.

Making yoghurt.

Household Chemicals and Change

Activities Associated with Other Subject Areas

Refer to " Notes on the Course ".

The Role of the Teacher

Refer to " Notes on the Course ".

PART II: ENERGY

Children live in a world in which things are moving and changing. Winds are blowing, men working, cars moving, fires burning, and plants growing all over the world. It is our first task to make children more aware of this, both in a factual sense and in an artistic sense. In the infant department, children have investigated many groups or systems of objects and found ways in which the members of the groups interact with one another, thus producing changes. Children now need experiences which will allow them to learn that changes are very wide-spread and are, in fact, a constant feature of our environment. The word " energy " will not be a new one to all children, but at this stage children may use it as a general term to cover those agents that bring about change. Children should come to understand that cars get energy from petrol, that people get energy from food, and that clocks get energy from being wound up or from the electricity supply; energy comes into the house in bags of briquettes, fire-wood, and groceries, and through the electric power lines. Children spend a lot of their pocket money buying energy. But application of energy to some things does not always make things happen the way we want them to. In every household and classroom are many machines, simple and complicated, which, when energy is supplied, do the work we want; and in this category come pencil sharpeners, can-openers, egg-beaters, vitamizers, and refrigerators.

The chief idea of which we can expect children to have some understanding as a result of work in this area is that change is wide-spread; that to make things happen or bring about change energy is required; that there are many kinds of energy such as heat and energy of motion; and that in everyday life man makes use of energy sources, often through machines.

Following On

Fire

Simple introduction to recognition and control of factors.

Investigation of safety procedures, both public and private.

Requirements of fire; kindling a fire; destructive power of fire; extinguishing fires.

Heating and Cooling

Different ways of producing heat.

Effects of heat on various materials—melting and evaporation.

Examples of the uses of heat in " doing things ", involving opportunities to develop abilities: isolating and controlling factors; making accurate observations; organizing data; writing clear accounts of activities undertaken.

Magnets

Experiences with magnets.

Discovering properties of magnets.

Batteries, Bulbs, and Wires

Observation of batteries.

Making circuits.

Finding out about conductors and non-conductors.

Bringing about changes.

Safety practices.

Experiences with Light

Light and change—changes in plants and animals due to variations in light conditions.

Lights and colours—mixing colours in various ways; coloured cellophane; light beams; mixing oil and water paints.

Bending light rays—informal work with magnifying glasses, lenses, binoculars, and telescopes.

Making Sounds

Producing sounds from various objects.

Designing, making, and using simple sound-producing instruments.

Changing pitch.

The connexion between sound and vibrations.

Human sounds.

Moving

The energy of moving things and its effects; using energy sources.

Moving water; water wheels.

Moving air; windmills; sailing boats.

Moving solids, marbles, sand.

Batteries.

Clock-work motors.

Rubber bands.

Home-made machines and simple devices that use energy sources (above).

Making Work Easier

Moving heavy loads—reducing friction.

Pulling out nails.

Making butter.

Wheels and cogs.

Activities Associated with Other Subject Areas

Refer to "Notes on the Course".

The Role of the Teacher

Refer to "Notes on the Course".

Branching Out

Fire

Comparisons of fuels, flames, inflammable materials.

Heating and Cooling—Activities Involving the Following:

Evaporation and cooling—methods of cooling; relationships between rate of evaporation and cooling, discovered as a result of work with methylated spirits, water-bag, butter wrapped in paper and butter wrapped in damp cloth.

Evaporation as it applies to humans and animals.

Thermometers—measuring freezing, melting, and boiling point; measurements made with a variety of materials; body temperatures of humans and animals; graphing temperature changes; differences in cooling rates of various warmed materials; making thermometers.

Scales.

Expanding and contracting.

Liquids, gases, and solids.

Things getting hot; transfer of heat in various media.

Keeping heat out or keeping heat in.

Insulation activities.

Magnets

Making magnets.

Fields of force.

The earth as a magnet.

Electricity

Currents and compass needles; making a current tester.

Effect of current on steel knitting needle and a nail.

Producing current with hand generator.

Making a telegraph transmitter and a receiver.

Electrical energy and other forms of energy.

Static Electricity

A variety of activities aimed at broadening pupils' experiences and stimulating discussion.

Experiences with Light

Making measurements of reflecting light rays; making periscopes.

Separating light into colours; combining colours to make white light.

Making light rays visible.

Discovering how a box-camera works.

Magnifying glasses and magnification.

Responses of living things to light.

Role of light in bringing about change in photographic films; exposure meters.

Working with Sound

Designing and making sound-producing instruments.

Measuring the distance over which vibrations from sound-producing objects can be detected; vibrations transmitted through various media.

Making Objects Move

Exploring the relationship between force and mass.

Overcoming inertia.

Model engines (petrol and steam).

Trains, cars, planes, and rockets.

Firing projectiles—work with marbles and jets of water to explore relationships between angle of elevation, distance travelled, and propelling force.

Galileo—the Solar System and Beyond

Happenings at a Distance

Transfers of energy.

Activities Associated with Other Subject Areas

Refer to "Notes on the Course".

The Role of the Teacher

Refer to "Notes on the Course".

PART III: LIFE

Essentially, each plant or animal develops individual adaptations that match common problems. It must get enough energy for life, whether from the sun or from suitable chemical compounds. It must absorb nutrient substances needed in the synthesis of its own type of cells. It must survive adverse climatic conditions, resist organs of disease, escape from being eaten, and reproduce—perhaps giving parental care to the next generation.

—*International Encyclopedia of Science,* Nelson, p. 351.

Living things not only share some common problems, but participate also in an interlocking relationship with one another and with the environment at large. Any study of life must pay some attention to these matters while attempting to bring some order into the variety which is such an important characteristic of life. The study must view particular forms of life as members of larger, constantly changing groups, and as individuals who are themsel[illegible] going constant change. These individuals are agen[illegible] in a process, producing new individuals who will themselves evolve to meet the requirements of the environment of which they are a part.

The most obvious starting point in this work for primary school children is the examination of the great variety of living things which exhibit many features of similarity as well as difference. The recognition of these features and the subsequent groupings of them allow for an extension of the simpler studies that were undertaken at the infant level. The teacher should keep in mind the purposes and the implications for the children's general intellectual development as well as the development of scientific knowledge, both of which were evident in the work of the lower grades.

Collecting information about animals and plants requires the development and the use of the ability to observe, record, and experiment, and the ability to make and to check inferences. Grouping the information develops knowledge of the ways in which classifications of organisms are made, although it must be emphasized that the formal scientific classifications are not appropriate at this stage.

The point is illustrated in this extract from a grouping made early in the year by a child in Grade IV :

Crawler	*Flying*	*Butterflies*	*Biters*
lizards	flies	casemoth	dog
caterpillar	bees	black swallow-tail	lion
	wasp	monarch	man
	moth		
	butterfly		

Hoppers	*Insects*	*Water*	*Singing*
grasshopper	ant	crabs	cricket
praying-mantis	locust	yabbies	
	ladybird	fish	

It should be obvious that a grouping such as this represents only a beginning ; but herein lies its value. Not only does it show starting points for further investigations by the child, but it also shows the level of consistency in the child's thinking. One is intrigued and delighted by the category " Biters " ; one is also given an insight into the working of a child's mind. Similar activities undertaken later in the year will provide evidence of the child's progress in scientific ability and, in a wider sense, as a thinker.

Gradually, a knowledge of some general features of plants and animals will develop. For example, from a study of many plants it may be concluded that green plants normally need light for survival—a conclusion that is derived from a grouping of several pieces of information. Just what particular ideas will come from experiences cannot be exactly predicted, but the suggested units of work set out on the following pages, and treated in some detail in the Curriculum Guide, are expected to lead towards the formation of the following general ideas :

1. *Living things exhibit great variety, but they also share fundamental similarities.*—Both similarities and differences can be noted in many structures and behaviours ; for example, food preferences, reactions to danger, methods of obtaining food. The particular similarities and differences noted will depend upon the animals and the plants studied.

2. *Living things interact with their surroundings.*—A piece of metal changes as a result of the action of the environment upon it. With living things this process is more dynamic and, in some instances, less noticeable. When man grows food he changes the vegetation covering the land, and in so doing he alters the land itself. He also uses the air about him in his breathing and in the process of manufacture. These changes are sometimes, but not always, obvious.

It is unlikely at this stage that this idea of interaction between living things and their environment will be expressed clearly by children, but their later understanding may depend to a large extent on the examples through which they study the ways in which animals and plants bring about changes in their surroundings.

3. *In the course of interaction with environment, living things themselves undergo change.*—Again, the activities carried out should develop ideas of how behaviour, growth, and so on are products of both the nature of the plant or the animal and the environment.

4. *Systematic knowledge of life has been gathered during man's interaction with the environment, and often this knowledge has been used by man for his advantage.*—An understanding of this idea is likely to develop incidentally, but there are many stories that present it in a very dramatic form. A number of these stories are suggested in the Curriculum Guide.

NOTE.—In all units it should be understood that the intention is to study plants and animals, including man, in a way that will make fruitful comparisons possible and which shows that many of the characteristics of living things can only be understood by examining them as part of, and in interaction with, their surroundings.

Following On

Collecting and Caring (more advanced activities than for younger children)

Collecting and caring for plants and animals ; caring for humans.

Collections of structures—bones, feathers, hair; worms, mussels, slugs, snails, slaters, spiders, ants, butterflies, moths, caterpillars, fish, frogs, lizards, tortoises, birds, white mice, guinea-pigs, rabbits, etc.

Plants—land and pond plants, flowering plants, cone-bearers, ferns, mosses, etc.

Groupings and Structures

Finding similarities and differences, using a broad sample of living things.

Classifications that children make should be logical and in accord with observations, but they should be children's groupings, not imposed adult schema at this stage.

Behaviours or What Living Things Do

Self care and protection—general descriptions of what a plant or an animal does—how fast it grows, what it uses as food, how it perpetuates the species, its responses to change; naturally and artificially produced crowding.

Needs; adjustment to environment.

Altering environment.

Life Stories

Beginnings, development, decay, and disappearance of living things, e.g. bean (or plant parts—fruit, leaf, twig, flower).

Role of other agents—predators, parasites, moulds; climatic environmental variation.

Men and Science

Activities Associated with Other Subject Areas

Refer to "Notes on the Course".

The Role of the Teacher

Refer to "Notes on the Course".

Branching Out

Collecting and Caring

Collecting and caring for plants and animals (more advanced activities than at the junior level).

Caring for humans—babies, sick people (see "Life Stories" below).

Collection and maintenance of populations of microscopic organisms (paramecium).

Groupings and Communities

Study of communities—plants, animals, self-regulating communities or eco-systems (small), such as beach, forest, swamp, waste land, vacant block, house and garden, school-ground, pond, fish-tank, ink-bottle, and infusions of hay and other vegetation.

Behaviours

As for junior level, but with investigations planned and carried out in a more systematic way; varying factors; more critical appraisal of explanations children suggest.

Life Stories

Reproductive mechanisms; incubation of an egg; development of chick embryo.

Diary; project; interest books on birth and development of young animals (pet cat, dog).

Hospitals; baby health centres.

Men and Science

Activities Associated with Other Subject Areas

Refer to "Notes on the Course".

The Role of the Teacher

Refer to "Notes on the Course".

NOTES ON THE COURSE

Activities Associated with Other Subject Areas

Language

The importance of language development has been indicated earlier. The activities suggested in the Curriculum Guide provide experiences in which language must be used if the child is to extract the maximum benefit. Interest books and topic books provide the means for linking English and science, to their mutual advantage.

Social Studies

It is possible that some of the activities undertaken will develop out of interests shown in social studies. At other times science may lead to work that may be more properly regarded as social studies. In any case, integration should be encouraged. Excursions should be undertaken where possible to initiate or to complete a series of activities.

Art and Craft Activities

Making pieces of simple apparatus and expressing aspects of the work in artistic form should be encouraged. The senior level activities on "Diffusion" and "Chromatography" provide examples of science studies that are admirably suited for exploitation in this fashion.

The emphasis should be on individual invention and creative use of materials rather than on copying the ideas of others.

Mathematics—Applied Number

Many of the activities in the Curriculum Guide involve estimating, measuring, and calculating. Tables and graphs may be used to record results. Children should also be encouraged to look at their organized data and to draw conclusions from them.

Present-day Application of Scientific Ideas

Almost all the work can lead to studies of how scientific ideas are used.

Excursions to suitable factories and places of work should also be arranged (where possible).

The Role of the Teacher

In brief, it may be said that the role of the teacher should be to stimulate children to investigate and to think for themselves. This is likely to involve the teacher in efforts to promote an atmosphere in which discussion will flourish and ideas for investigation will emerge. At the same time, the teacher should attempt to anticipate likely lines of inquiry and have suitable materials on hand. The teacher should encourage children to proceed independently, but he may need to help by initiating inquiries and giving other assistance where necessary. Illustrations of the role of the teacher in particular situations will be found in the Curriculum Guides.

Conservation

The "Life" section of the course is largely an environmental study and, as such, is very much concerned with conservation. It is believed that a positive attitude towards conservation of natural resources—of plants, animals, land, and indeed the whole landscape—is not likely to develop out of set lessons. On the other hand, an ecological approach as suggested in the Course and the Guide may have some chance of success. An approach of this sort is only possible if a wide variety of plants and animals is kept, and not simply talked about in their absence. Furthermore, these plants and animals should not be studied separately but should be seen as parts of a complex, interacting environment.

Special Agencies

These include the following :

- The Gould League.
- The Victorian State Schools' Horticultural Society.
- The Institute of Applied Science.
- The National Museum.
- The Natural Resources Conservation League.
- The Australian Conservation Foundation.

Each of these agencies can be of assistance in achieving the aims of the course. Information appears from time to time in the *Education Gazette* in connexion with their work, and they may be approached directly.

Primary—Secondary Transition

The course is not intended to be a watered-down version of secondary school science. Research evidence suggests that it is very doubtful whether primary school children are ready for the abstract concepts of science that can be taught and understood at the secondary level. *Primary school teachers who give instruction in these concepts may do more harm than good.* The real value of science at this level lies elsewhere. It is believed that secondary school science teachers would welcome children from the primary school who have a wide background of experience and who have developed some important skills and attitudes in science. This would be preferable to the knowledge of a few facts and a premature acquaintance with abstract concepts which would be better understood later.

Individual Differences

The course aims at providing children with experience from which each child should be able to benefit according to his abilities. Children of widely diversified abilities and attainments can work together in science. They may work at times as a class, in a group, or individually. The follow-up work—making individual booklets, for example—provides each child with opportunities to organize his own thoughts in his own way and at his own level. These interest books, and sometimes art and craft work, can provide most valuable insights into the developing mind of the child. It should hardly be necessary to add that at all times the child should be encouraged to give his best in his work and to judge his own efforts, by comparing them always with his own earlier efforts.

Evaluation

Some methods of evaluation have already been indicated above. Evaluation should be a matter of individual assessment, with the child today being compared with the same child yesterday rather than with some other child. Evaluation should be largely concerned with watching, listening, and reading—with what the child does, says, and writes, all of which can provide evidence of the child's thought processes—rather than with tests of the child's ability to recall isolated facts. Such tests may have little value. The other forms of evaluation are of far more use in assessing the development of the children throughout the year.

Materials and Equipment

Very little special equipment is necessary ; where it would be useful it will be referred to in the Curriculum Guide. The following materials would be of value :

- Hand lenses.
- Alloy magnets.
- Fish-tanks.
- Microscope.
- Cages.
- Dry cells, torch globes, and coated wire.
- Suitable heat sources. The small solid fuel tablets available at most hardware stores will be useful.
- Thermometers.

Safety

At all times teachers should proceed with due regard for the safety of the children. Precautions such as those indicated in the Curriculum Guide should be taken. Many of the activities provide valuable opportunities to promote desirable safety attitudes. Great care should be taken in storage and display of articles and substances that might be dangerous to children.

Method

The Curriculum Guide contains many suggestions on methods of approach. It is suggested that the aims of the course are most likely to be achieved if children's interests are developed. A method that emphasizes instruction is not desirable. *The Curriculum Guide should be regarded simply as source material showing how ideas might be followed up. The units given there should under no circumstances be regarded as outlines for class lessons.*

Yearly–Weekly Programs

It is important to ensure that over-careful planning does not restrict the natural flow of inquiry and discovery. The teacher may guide investigations, but he should also allow them to follow as naturally as possible from the children's own interests and the natural resources of the locality.

Much planning will be needed, often to anticipate the lines of development a topic may take. This planning cannot always be set out in detailed weekly units, and in many cases it may be desirable to note progress after a topic or a sub-topic has been dealt with. The children's work in itself is a valuable record of their activities.

It is not possible to state the number of activities that should be covered in a year. Some teachers have found that eight fairly wide-ranging activities can be undertaken, but this is not a figure that would apply in every case. In some classes a large-scale investigation of life might be the major activity during one term, and other aspects of science might be treated more or less briefly during this time. During the rest of the year these "other" aspects would probably be treated in more detail.

Although children's interests should largely govern the selection of activities, teachers should endeavour where possible to maintain a balance between the types of activities undertaken, so that the broad topics of matter, energy, and life all receive attention.

Time Allotment

Primary school science is an important subject in its own right, but its themes carry over into other subject areas. It is necessary, therefore, that the subject as such be given an adequate allocation of time and that opportunities be taken to integrate the work with other subjects where this is appropriate.

The nature of the suggested activities makes it difficult to stipulate a fixed time allotment. Consideration should be given to the use of a block timetable and of an approach that allows work in a number of subjects to develop naturally from a particular theme or interest. For example, during one week ideas similar to those described in the unit "Water in Food" might be under investigation. Activities begun one morning after recess could lead to topic-book work which might be continued during the afternoon and completed, after further activities, the following day. During this period the work done might include applied mathematics (graph work), English (discussion, writing, and library investigation), and perhaps even art and craft work. More work on the topic might be carried out during the following week.

OUTLINE OF CURRICULUM GUIDE MATERIAL

BEGINNING SCIENCE

How To Begin

Part I: Discrimination and Classification

Using a variety of senses to investigate materials.

Ordering observations, sorting and classifying in accordance with schemes children devise themselves.

Part II: Interactions and Change

Further multi-sensory activities, with more emphasis on observations of change and on manipulations leading to change.

Inanimate materials.

Energy and forces.

Life.

Appendix I: Collecting and Caring

Appendix II: Time

FOLLOWING ON

How To Begin

Developing Abilities

Part I: Matter

A. Nature of Materials

Collections.

B. Properties and Change

Separating materials.

Soaps, fats, and oils.

Water in food.

Plaster and cement.

Solutions, growing crystals, rock candy.

Bread, toffee, honeycomb, ginger beer, and cheese.

Making perfume.

Changes of state (see Energy unit "Heating and Cooling").

Rocks.

Wearing away the earth.

Part II: Energy

Fire.

Heating and cooling.

Magnets.

Batteries, bulbs, and wires.

Experiences with light.

Making sounds.

Moving.

Making work easier.

Part III: Life

Collecting and caring.

Groupings and structures.

Behaviours, or what living things do.

Life stories.

Men and science.

BRANCHING OUT

How To Begin

Developing Abilities

Part I: Matter

A. Nature of Materials

Comparisons of liquids.

Diffusion through liquids.

Separating materials.

Rising liquids.

Chromatography.

Hardness, brittleness, and elasticity.

Threads and fibres.

Glass, bricks, pots, and a kiln.

B. Bringing about Change

Corrosion.

Results of change.

Boiling an egg.

Making coal gas.

The souring of milk.

Household chemicals and change.

Part II: Energy

Fire.

Heating and cooling.

Magnets.

Electricity.

Static electricity.

Experiences with light.

Working with sound.

Making objects move.

Galileo—the solar system and beyond.

Happenings at a distance.

Part III: Life

Collecting and caring.

Groupings and communities.

Behaviours.

Life stories.

Men and science.

OTHER ACTIVITIES AS DEVELOPED IN THE SCHOOL MAY BE ADDED

A. C. Brooks, Government Printer, Melbourne.